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FIELD EVALUATION OF SOME OKRA (*ABELMOSCHUS ESCULENTUS* L. MOENCH) VARIETIES IN THE HUMID TROPICS, RIVERS STATE

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ABSTRACT: *A study on the suitability of seven different Okra Varieties (Abelmoschus esculentus L. Moench) was conducted at the Rivers State University Teaching and Research Farm Nkpolu-Oruworukwo, Port Harcourt. The seven Okra varieties comprise of five exotic and two landraces (Kirikou, Madison, Clemson Spineless, Hire, Sahari, Ogbami and Chuku-chuku) were planted in a randomized complete block design (RCBD) with five replications. The results obtained showed that Madison variety had the highest (P<0.05) mean plant height followed by Clemson spineless variety. Clemson Spineless and Madison varieties significantly (P<0.05) matured earlier at 10 weeks after planting. Clemson Spineless variety consequently produced higher (P<0.05) yield of okra (29.13 t/ha) and supported higher okra growth, number of leaves and leaf area than other studied varieties. A positive correlation was established between total weight of fresh okro and 8th weeks leaf area (r = 0.85); total insect count and 8th weeks leaf area (r = 0.95) respectively. There were significant differences (P<0.05) on the insect pest damage on the leaves of the studied okra varieties. The result established that the Okra flea beetle Podagrica spp. remain the major insect pest of Okra in the study area causing very severe damage (defoliation) on the leaves of the tested exotic okra varieties. The experimental results however revealed higher susceptibility of the two land races (Ogbami and Chuku-chuku) to waterlogged environment due to excessive heavy rainfall. This experiment therefore recommends the cultivation of Clemson Spineless, Sahari and Madison okra varieties to our farmers for higher and better Okra production.*

KEYWORDS: Okra, varieties, exotic, landraces, Weeks after Planting (WAP).

INTRODUCTION

Okra, *Abelmoschus esculentus* L. Moench (Linnaeus, 1753) is a warm season crop belonging to the family Malvaceae and believed to be originated from Ethiopia (Lamont, 1999). Okra plants are presently grown commercially in many countries such as India, Japan, Turkey, Iran, West African countries, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Myanmar, Malaysia, Thailand, Brazil,

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Ethiopia, Cyprus and in the Southern United States (Benjawan *et al.*, 2007; Qhureshi, 2007; Purseglove, 1987). It is cultivated in tropical, sub-tropical and warm temperate regions around the world including Nigeria (National Research Council, 2006). Nigeria produced 2.1 million tonnes of okra in 2017 (21.4% of world production) making it second to India (FAOSTAT, 2018).

A. esculentus is adapted to wide varieties of soil, but a deep fertile sandy loam with good drainage and a soil pH of about 6.0 to 6.8 is optimum (Eke *et al.*, 2008; Greensil, 1976). Okra requires a moderate rainfall of 800-1000 mm well distributed to produce its young edible fruits. An average monthly temperature range of 20°C to 30°C is considered optimum for growth, flowering and fruiting (Rice *et al.*, 1987; Tindall *et al.*, 1986). Okra has many varieties, which ranges from the popular lady finger that may be above 2 meters tall with fruits that are as long as human finger, to dwarf, early maturing and highly branching varieties with small to medium sized fruits. The shape and color of okra fruit varies with variety. Okra may be short, long, smoothed or ribbed and cylindrical; it may also be green, reddish-green or pale green to yellow and its fibrous fruits or pods contain round, white seeds (Rice *et al.*, 1987). Fifty kilogram/ha of Nitrogen, Phosphoric acid and Potash are usually applied to provide sufficient nutrients to produce good yield (Greensil, 1976).

Economically, okra is used chiefly as a fresh vegetable with high nutritive value. The leaves having higher protein content than the pods (Avona and Juo, 1984). Tindall (1979) stated that the fruits of okra contain the following: 70ml of calcium, 90ml of water, 6ml of carbohydrates, 2gm of iron, 2gm of protein, fat is negligible, vitamin ‘’A’’ potency is 150 IU, 1g of thiamine and 25mg of ascorbic acid. Okra is mainly cultivated for its “pods” which are cooked and eaten in African countries like Nigeria, Egypt and Sudan. It is also important in other tropical areas including Asia and South America, fresh okra fruits are used as vegetable while the roots and stems are used for preparing brown sugar. Okra pods are used for oil extraction (Chauhan, 1972). The stem contains fibers of low strength used domestically in making fish line traps (Greensil, 1976). The protein found in okra is very important in human diet, it helps to build muscle tissue and make up enzymes which control all the hormones that control the organs. The soluble fibre in okra helps to lower serum cholesterol, reducing the risk of heart disease, the other half is insoluble fibre which helps to keep the intestinal tract healthy decreasing the risk of some form of cancer especially colorectal cancer. Nearly 10% of the recommended level of vitamin B6 and folic acid are present in half a cup of cooked okra, vitamins are required for good vision, help bone growth, proper circulation of blood and aids digestion (Wolford and Banks, 2006). Okra is a good source of calcium which helps to keep bone strong and lessen the chance of fractures (Grubben and Denton, 2004). The seeds however can be roasted and used as substitute for coffee (Farinde and Owolarafe, 2007).

Schrippers (2000) reported 25-40 t/ha as the expected yield of okra depending on the variety, prevalence environmental conditions and agronomic practices. Okra yield of 15 t/ha and 16.8 t/ha have also been reported in the lowland humid tropical soils of southern Nigeria and in the West

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Indies respectively. This yield shortfall has been attributed to environmental factors such as rain, wind, temperature, humidity etc. and endemic pests and diseases (Ahmad and Tulloch-Reid, 1968; Chheda, 1977). Zuofa *et al.* (1989) emphasized that Okra yields on farmers' field in Nigeria are considerably lower averaging about 2-5t/h due to environmental factors such as rain, wind, temperature, humidity etc. and pests and diseases.

Various okra varieties have therefore been successfully selected for particular countries depending on their agro-ecological suitability (drought, temperature, Insect pests and diseases). In the United State, Okra was restricted to the southern part of the country, but the development of new drought resistance cultivars with early maturity allows cultivation in the north (Mota *et al.*, 2000; Hill, 2008). The predominant high yielding Okra varieties grown in Florida, USA are Annie Oakley, Cajun Delight, Clemson Spineless and Spike (Simonne and Dukes, 2010). Okra constitutes a major part of Nigerian agricultural production, but its productivity is known to be generally low and this is attributed to environmental factors (droughts, poor soil fertility due to poor drainage), soil inhibiting nematodes and insects' pests amongst others (Epidi, 1996). Insect pest like White flies (*Bermisia spp.)* and flea beetles tends to be both sporadic and localized so far as serious damage is concerned (Hill and Waller, 1988). Flea beetles (*Podagrica spp.*) had been reported to be more predominate and destructive in Rivers State of Nigeria (Epidi, 1996; Akinlosotu, 1979). Flea beetles feed on the okra leaves and create numerous holes thereby reducing the plant yield, delay plant development and delay occurrence of photosynthesis (NRI, 1996).

Various management techniques have been adopted in recent time in the management of insects' pest and diseases of okra and other crops. Some of these techniques are chemical control, cultural practices and host plant suitability and resistance (Onuegbu, 2002; Dent, 1991; Kumar, 1984; Akinlosotu, 1979). The use of chemicals has resulted to serious environmental hazards and elimination of beneficial insects while cultural practices are very painstaking and time consuming (Mohammed, 2000). The use of host plant resistance that can withstand pest infestation, drought and other environmental challenges might be promising (Dimkpa *et al.*, 2010; Appiah *et al.*, 2007). Kumar (1984) stated that host plant resistance is a potential pest management method which represents the inherent ability of crop plants to restrict, retard or overcomes pest infestations. The incorporation of host plant resistance in an Integrated Pest Management strategy for the management of the okra pest and diseases is highly imperative.

Dhaliwal *et al.* (2013) reported that plant with constitutive drought and pest resistance possess genetically inherited qualities that results in a plant of one variety being less damaged with higher yield than a susceptible plant lacking these qualities. Thus, continuous selection of most suitable plant for specific Agro-ecological zone is ongoing in most part of the world. It is therefore highly imperative to select okra varieties that will be able to withstand adverse environmental factors, including insect pests and diseases in order to enhance its productivity in our environment. It is

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expected that most suitable okra varieties will be able to overcome the biotic and abiotic stresses prevalent in its tested Agro-ecological system with higher productivity at an earlier maturity time.

Hence, assessing the varietal suitability of seven different okra varieties in the Rivers State University Teaching and Research Farm will help increase the yield of the crop and improve Nigeria agricultural productivity.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the Rivers State University Teaching and Research farm. The farm is located at latitude $04^0$8"59"N and longitude $06^0$10"90"E of the equator; with an elevation of 1.8m above sea level. The area lies in the humid tropical zone. The annual rainfall ranges from average of 2000mm to 4500mm, relative humidity in the area is high ranging from 75-90%, while the monthly temperature ranges from 28^{o}C and 33^{o}C (RISADEP, 1995).

Sources of Experimental material

Seven Okra varieties (five exotics and two local landraces) were purchased from Agricultural Development Project (ADP). The exotic varieties used were Kirikou F1, Madison F1, Clemson Spineless, Hire and Sahari while the local landraces was Ogbami and Chuku-Chuku.

Land Preparation and Experimental Layout

The land was cleared, ploughed and harrowed by tractor before planting. The experimental area used was 228m^2 which was later converted to Hectare and the number of plots in the experimental area is 35.

Method of Planting

The seeds were presoaked in water one hour before sowing to identify the viable seeds and hasten germination. Three seeds per hole were planted and after 7 days of emergence, the germinated okra was thinned to a stand per hole. The total number of crop planted was 525 plants.

Weed control

Weeding was done manually with the use of hoe three weeks after planting and subsequent weeding was done at five weeks.

Parameters assessed

Plant Height: Plant Height was taken at 4th, 6th and 8th weeks after planting.

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Leaf Area: The leaf area was taken at 4th, 6th and 8th weeks after planting. This was calculated as the product of the total length and breadth at the broadest point of the longest leaf on the plant (Musa and Usman, 2016).

Leaf area = Lamina length × maximum width × K

Where K = Correction factor 0.62

Number of Leaves: The number of leaves was taken at 4th, 6th and 8th weeks after planting.

Number of pods/weight of pods: The pods was harvested, counted and weighed respectively.

Insect Count: The direct counting method was used because the insects are visible to the naked eyes. The insects were counted twice every week beginning from the fourth week of planting to eight week.

Damage Assessment on the Leaf: Visual assessment of damage was used (Compton, 1991). The number of holes on the leaves of the Okra plant was used as bases and this was rated into a 5-grade scale as slated below:

0 hole – No damage

1-5 holes – Slightly damage

5-10 – Average damage

10-15 holes – Severe damage

15 holes or above – Very severe damage

Experimental Design

The experimental design used in this experiment was Randomized complete block design (RCBD) and replicated five (5) times.

Statistical Techniques

Collected experimental data was arranged in excel spreadsheet and subjected to analysis of variance using Minitab software and the significance differences between the Okra varieties were separated using Tukey's test (Minitab, 2010).

RESULTS

The mean plant height of the Okra varieties at 4, 6 & 8th weeks after planting are illustrated in Table 1. Plant heights generally increased with the age of the plant across the test varieties of Okra.

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Madison variety recorded the highest mean significant height of 6.37 cm and 16.99 cm at 4th and 8th weeks respectively followed by Clemson Spineless with the mean value of 5.87cm and 16.48 cm respectively, Clemson spineless had the highest plant height mean in 6th week. The lowest mean height of 2.41 cm was recorded in Chuku-chuku at 4 weeks after planting (WAP). There was no significant difference ($P<0.05$) between Madison and Clemson Spineless varieties at 6th and 8th weeks after planting. Wilting occurred in the two landraces (Chuku-chuku and Ogbami) after 4WAP.

The leaf areas of the various Okra varieties were significantly different ($P<0.05$) at week 4, 6, and 8th after planting (WAP). Madison Okra variety also recorded a significant higher leaf area of 16.45 cm^2 at 4 WAP followed by Clemson Spineless with the mean value of 12.42 cm^2 and the lowest was recorded in Chuku-chuku with the mean value of 3.91cm^2 (Table 2). Clemson spineless variety had the highest leaf area at 6 and 8 weeks after planting with the mean value of 90.20 cm^2 and 236.00 cm^2 respectively. Ogbami and Chuku-chuku landraces were low in leaf area. There were significant differences ($P<0.05$) between the studied Okra varieties in relation to the mean number of leaves at 4, 6 and 8 WAP. The highest leaf mean number of 5.40 and 5.00 was recorded by Madison at 4 and 6 WAP respectively, while Clemson Spineless had the highest mean number of 7.47 at 8 WAP with the land races recording no leaves at 6 and 8 weeks (Table 2). Also, there was no significant difference ($P>0.05$) between Madison and Clemson spineless in number of leaves at 4 and 6 weeks respectively.

The mean numbers of flower pod on the various Okra varieties were significantly different ($P<0.05$). Clemson Spineless had the highest mean number of flower pod (35.27), followed by Sahari (21.20) and lowest was recorded in Ogbami and Chuku-chuku varieties with a mean flowered pod of 0.0 respectively. The Okra flea beetles *Podagrica spp*. (Plate 1a) was predominantly observed on the studied Okra varieties with the dominance of *Podagrica uniformis* than *Podagrica sjostedti*. The experimental result revealed a high number of *Podagrica uniformis* on the exotic okra varieties with a significant highest ($P<0.05$) mean number of 41.40 recorded in Clemson Spineless variety followed by Madison 26.60 and 22.50 for Sahari (Table 3). The mean yield of Okro on the various varieties revealed that Clemson Spineless and Madison varieties were the first to produce matured fresh Okro fruit at 10th week with Clemson Spineless recording the highest yield of 29.13t/ha followed by Sahari (17.68t/ha), Madison (9.72t/ha) and Hire (9.27t/ha) while Kirikou variety had the lowest yield of 4.54t/ha (Table 3).

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Table 1: Plant Height of the Seven Okra varieties

Varieties	Plant Height (cm)		
	4 WAP	6 WAP	8 WAP
Clemson Spineless	5.87^{ab}	12.44^{a}	16.48^{a}
Sahari	5.18^{ab}	7.41^{b}	9.44^{b}
Madison	6.37^{a}	12.42^{a}	16.99^{a}
Hire	3.13^{cd}	4.66^{c}	8.13^{b}
Kirikou	4.43^{bc}	4.75^{bc}	7.28^{b}
Ogbami	3.22^{cd}	0.41^{d}	0.60^{c}
Chuku-Chuku	2.41^{d}	0.00^{d}	0.00^{c}

*Means that do not share same letter are significantly different (Tukey method at 95% Confidence level)

Table 2: Leaf Area and Number of Leaves of the Seven Okra varieties

Varieties	Leaf Area			No. of leaves		
	4 WAP	6 WAP	8 WAP	4 WAP	6 WAP	8 WAP
Clemson Spineless	12.42^{b}	90.20^{a}	236.00^{a}	5.20^{a}	4.80^{a}	7.47^{a}
Sahari	8.65^{c}	11.90^{d}	30.33^{d}	4.53^{b}	2.73^{b}	2.33^{c}
Madison	16.45^{a}	35.92^{b}	100.20^{b}	5.40^{a}	5.00^{a}	4.87^{b}
Hire	4.97^{d}	21.10^{c}	67.87^{c}	4.00^{b}	2.20^{b}	2.73^{c}
Kirikou	9.21^{c}	16.74^{cd}	24.31^{d}	4.47^{b}	2.73^{b}	3.07^{c}
Ogbami	4.05^{d}	0.26^{e}	0.00^{e}	4.40^{b}	0.53^{c}	0.00^{d}
Chuku-Chuku	3.91^{d}	0.00^{e}	0.00^{e}	4.00^{b}	0.00^{c}	0.00^{d}

*Means that do not share same letter are significantly different (Tukey method at 95% Confidence level)

Table 3: Number of flowered pods, Total yield and Insect count of the Seven Okra varieties

Varieties	No. of flowered Pods	Total Yield t/ha	Insect Count
Clemson Spineless	35.27^{a}	29.13^{a}	41.40^{a}
Sahari	21.20^{b}	17.68^{b}	22.50^{c}
Madison	15.13^{c}	9.72^{c}	29.60^{b}
Hire	11.40^{d}	9.27^{c}	21.80^{c}
Kirikou	5.80^{e}	4.54^{d}	21.27^{c}
Ogbami	0.00^{f}	0.00^{e}	0.00^{d}
Chuku-Chuku	0.00^{f}	0.00^{e}	0.00^{d}

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*Means that do not share same letter are significantly different (Tukey method at 95% Confidence level)

The regression analysis showed a significant difference ($P<0.05$) between total weight of fresh okro and leaf area revealing a positive correlation ($r = 0.85$) as the total weight of fresh Okro increases with increment in the leaf area (Figure 1). There was a positive correlation between total insect count and leaf area with $r = 0.95$, this therefore indicates that as the leaf area increase, the total insect count also increases (Figure 2). The leaves were severely damaged by the insect pests *Podagrica spp.* (Plate 1a) in all the okra varieties. These insects caused the appearance of large irregular holes on the leaves (Plate 1b - 1f). The numbers of feeding holes found on the leaves of each of the variety was more than 15 holes and were rated as very severe damage (Table 4). Thus the exotic plant leaves were highly damaged by the leaf eating beetles *Podagrica spp*. Clemson Spineless recorded the highest leaf damage followed by Madison at both at 5th and 7th WAP. Although, the leaf damage on the studied varieties were not significantly different at 5% probability level among the exotic okra varieties (Kirikou F1, Madison F1, Clemson spineless, Hire and Sahari).

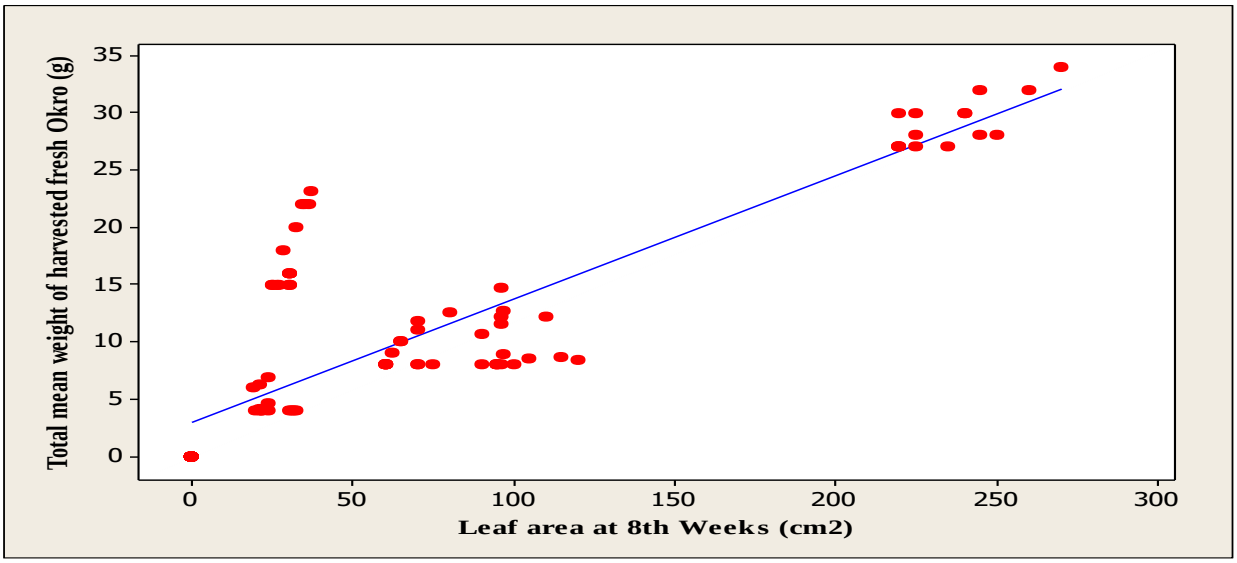

Figure 1: Regression for total weight of fresh Okro vs leaf area at 8thweeks summary report

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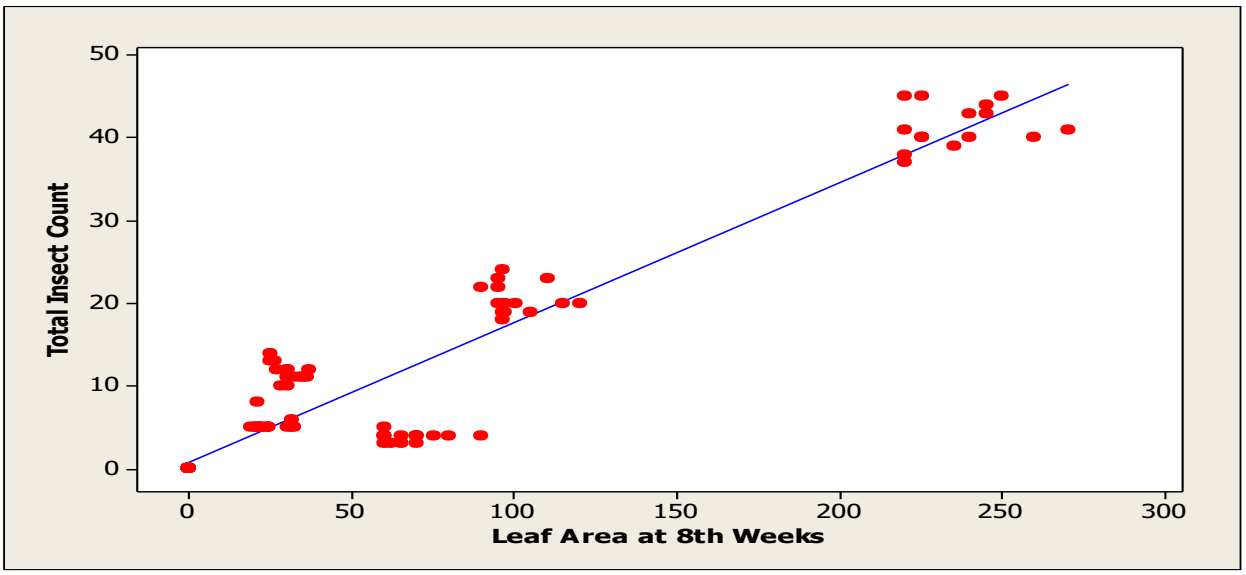

Figure 2: Regression for total insect count vs 8th Wk leave area summary report

Table 4: The Number of *Podagrica spp*. and its damage on the studied Okra varieties

VARIETIES	DAMAGE RATING AT 5TH WEEK WAP	DAMAGE RATING AT 7TH WEEKS WAP
Clemson Spineless	Severe damage	Very severe damage
Madison	Severe damage	Very severe damage
Hire	Severe damage	Very severe damage
Kirikou	Severe damage	Very severe damage
Sahari	Severe damage	Very severe damage
Ogbami	-	-
Chuku-chuku	-	-

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Plate 1a: Image of *Podagrica spp*.

Plate 1b: Very severe damage by *Podagrica spp*. on Madison Variety

Plate 1c: Very severe damage by *Podagrica spp*. *spp*. on Sahari on Kirikou Variety

Plate 1d: Very severe damage by *Podagrica* Variety

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Plate 1e: Very Severe damage by *Podagrica spp.* Plate 1f: Very Severe damage by *Podagrica spp*. on Clemson on Hire Variety Spineless Okra Variety

DISCUSSIONS

This experimental research therefore revealed that Madison variety had the highest plant height but was not significantly different from Clemson spineless. It is worthy to note that the land races Chuku-chuku and Ogbami varieties wilted/died after 4 weeks and therefore recorded no leaf development and pod formation at 6 and 8 weeks respectively. This wilting/death of the landraces might be attributed to their inability to withstand waterlogged area as heavy rain fall in the month of July and August exceeding 2000mm briefly flooded the experimental site. Kochlar (1981) stated that okra production in Nigeria is done mainly in the warm season, although it can be grown all year round depending on the varieties. Thus, Chuku-chuku and Ogbami land races may be among the varieties of Okra that could not tolerate heavy down pour as the moderate rainfall needed for production of young edible fruits is 800-1000 mm (Tindall *et al.*, 1986) and thrives best in a moist friable, well-drained soil (Eke *et al.*, 2008). It is important to note that the exotic varieties (Madison, Clemson spineless, Hire, Kirikou and Sahari) survived the flooded environment and thus could be reported to be tolerant to flooded soil. The experimental results attest the earlier reports of Majanbu *et al.* (1985), Mota *et al.* (2000) and Hill (2008) that some okra varieties are tolerant to drought stress.

Clemson Spineless plant produced broader leaves thereby making the variety significantly higher in leaf area and number of leaves compared to other varieties used in this research work. Clemson Spineless variety was the first to flower at the 6^{th} week with Clemson Spineless recording the highest number of flowers. This early flowering might be due to presence of broader leaves which encouraged higher photosynthetic activities. This corroborates the findings of Baraka (2019) who stated that large leaf development produces enough photosynthetic surfaces for rapid growth. This early flowering of Clemson Spineless also resulted to early production of matured okro fruits and higher yield compared to the rest studied varieties. This result support the report of Simonne and Dukes (2010) that Clemson Spineless variety was among the predominant high yielding and early maturing Okra varieties grown in Florida, USA.

The Okra flea beetles *Podagrica spp*. was predominantly observed on the studied Okra varieties with the dominance of *Podagrica uniformis* than *Podagrica sjostedti*. This observation was in conformity with the findings of Agunloye (1986) who reported similar trend in the population of *Podagrica uniformis* than *Podagrica sjostedti* and also with that of Emosairue and Ukaegbu (1994) who recorded high population number of *Podagrica uniformis* than *Podagrica sjostedti* in Calabar humid area. The experiment confirms that *P. uniformis* is the main and popular insect pest of Okra in Rivers State causing severe damage (holes) on the Okra leaves. The statement agrees with the works of Epidi (1996) and Akinlosotu (1979) who reported that *Podagrica spp*. is the most predominant insect pest of Okra in humid tropics.

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Clemson Spineless had the highest number of insect colonization which might be attributed to its high number of broad leaves. The leaves were severely damaged by the insect pests *Podagrica spp.* in all the okra varieties. These insects caused the appearance of large irregular holes on the leaves which was in accordance with the report of NRI (1996). The numbers of feeding holes found on the leaves of each of the variety was more than 15 holes and were rated as very severe damage. Thus all the plant leaves were highly damaged by the leaf eating beetles *Podagrica spp*. Clemson Spineless recorded the highest leaf damage followed by Madison at both 5th and 7th WAP. It is also very important to note that the high level of leaf damaged by the feeding of the Flea beetles *Podagrica spp.* would directly reduce the plant yield. NRI (1996) recorded that the very severe feeding of the flea beetles on okra leaf led to loss of chlorophyll causing reduction in the photosynthetic ability of the plant which invariably reduce yield.

5 CONCLUSIONS

This study assayed the varietal suitability of seven okra varieties in which Clemson spineless was significantly higher in number of leaves, number of flowered pods, leaf area, yield and insect count followed by Madison, Sahari, Hire, Kirikou, Ogbami and Chuku-chuku. It also revealed that the five exotic okra varieties (Clemson spineless, Madison, Sahari, Hire, Kirikou) were susceptible to *Podagrica spp.* and tolerant to flooded environment. It further showed that the landraces (Ogbami and Chuku-chuku) used in this experiment were highly susceptibility to flooded environment.

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